

From Science to Regulation-- ***(With the additional perspective of ten months of on-the-job training)***

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Chair's Seminar, Air Resources Board
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Outline

- Four regulatory issues with evolving science
 - Vehicle exhaust, atmospheric chemistry, and smog (a retrospective)
 - Particles and health
 - Oxides of nitrogen
 - Global warming
- Some successes and challenges



Four regulatory issues with evolving science



Regulatory Issue #1

VEHICLE EXHAUST, ATMOSPHERIC CHEMISTRY, AND SMOG

(A retrospective)



1940s: Los Angeles



County air pollution
control districts established

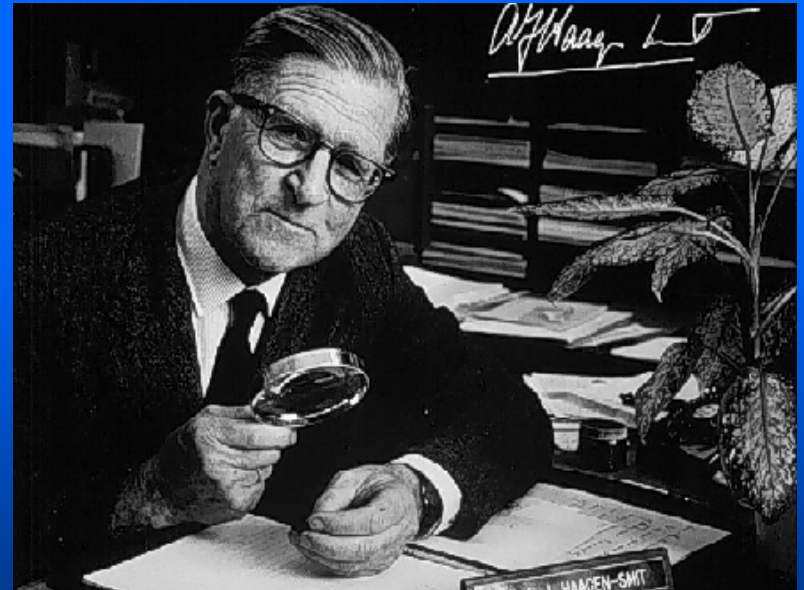


2.8 million vehicles



1950s: Photochemical smog described by Prof. Arie Haagen-Smit

- $\text{HCs} + \text{NO}_x \rightarrow \text{oxidants}$
- Automotive source



4.5 million vehicles



1960s: automotive emissions controls

- Motor Vehicle Pollution Control Board
- California positive crankcase ventilation (PCV) control
- California authority to set own motor vehicle emission standards
- Tailpipe standards for CO, HC
- California Air Resources Board (CARB)
- Prof. Haagen-Smit first chair (1967)

8 million vehicles



1970s: U. S. Clean Air Act

- U.S. EPA, 1970
- Los Angeles ozone 0.58 ppm
- CARB automotive NO_x standards, 1971
- National ambient air quality standards, 1971
- 2-way, 3-way automotive catalysts

12 million vehicles



1980s: expanding regulation

- In-use compliance testing
- Low emission vehicle (LEV) standards
- On-board diagnostics (OBD) rule
- Toxic air contaminant bill



1990s: tightening standards

- Cleaner burning gasoline program
- Zero emission vehicle (ZEV) program
- California diesel fuel introduction
- Smog check II
- LEV II standards (98+% reduction)
- MTBE ban



2000s: climate change

- No Stage 1 smog alerts (0.20 ppm O₃) in South Coast Air Basin
- Diesel risk reduction program
- AB1493 (Pavley) motor vehicle greenhouse gas emissions reduction
- Climate change action plan for California
- AB32 California Global Warming Solutions Act of 2006



Regulatory Issue #2

PARTICLES AND HEALTH

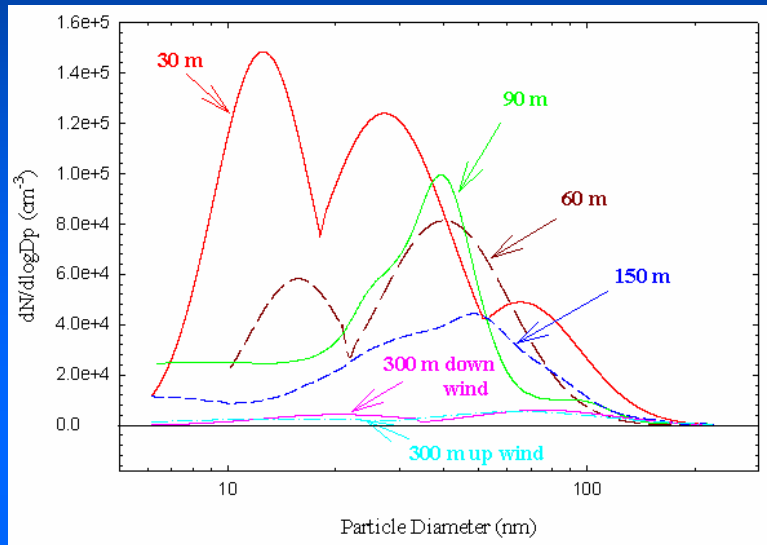


Particle health effects issues

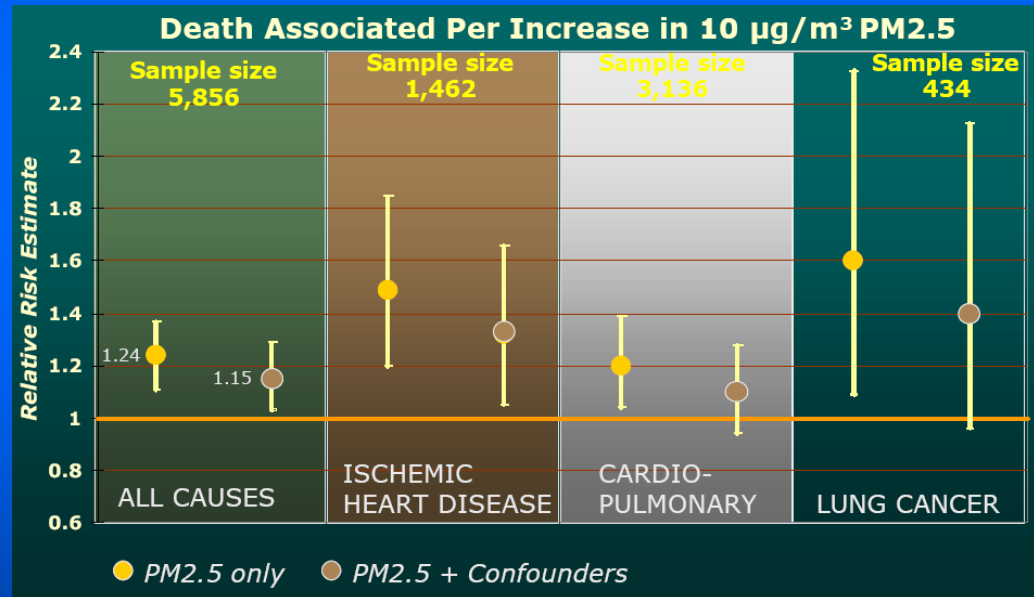
- Understanding of effects has changed dramatically: cardiovascular vs pulmonary
- Science base: toxicology to epidemiology
- Short term and long term exposures
- Importance of size and composition?
- PM_{10} , $PM_{2.5}$, $PM_{0.25}$ and/or number standard?



Getting exposure right



C. Sioutas, near freeway studies



M. Jerrett, zip code linked exposures (2005)



Regulatory Issue #3

OXIDES OF NITROGEN



Nitrogen oxygen chemistry

- NO (combustion)
 - $\text{N}_2 + \text{O} \rightarrow \text{NO} + \text{N}$
 - $\text{O}_2 + \text{N} \rightarrow \text{NO} + \text{O}$
- NO₂ (combustion, troposphere, catalysis)
 - $\text{NO} + \text{OH} \rightarrow \text{NO}_2 + \text{H}$
 - $\text{NO} + \text{O}_3 \rightarrow \text{NO}_2 + \text{O}_2$
 - $\text{NO} + \text{O}(\text{surface}) \rightarrow \text{NO}_2$
- N₂O (soil, stratosphere, catalysis)
- HONO (combustion, troposphere)
- HONO₂ (troposphere)



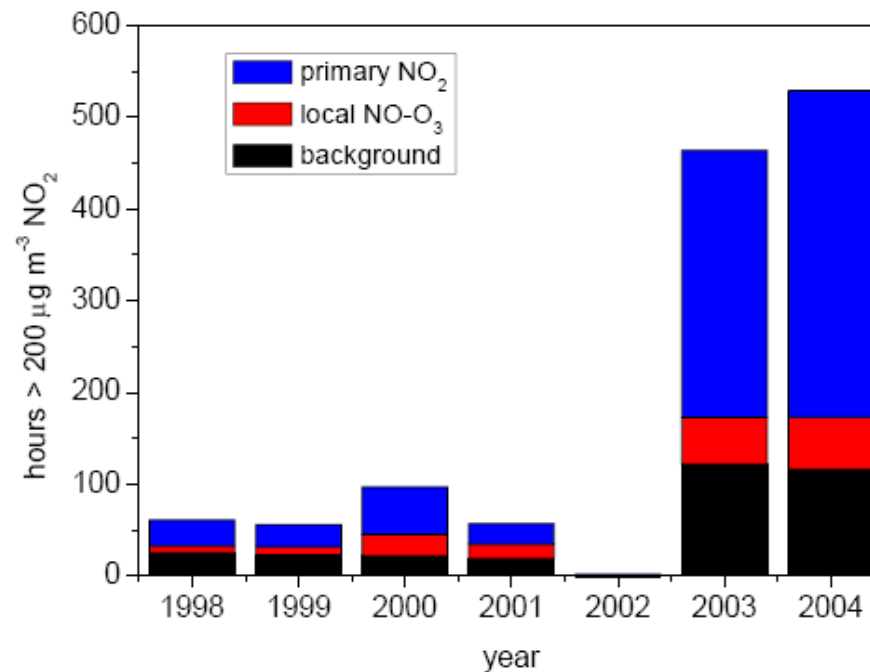
Nitrogen dioxide issues

- Air quality standard
 - US EPA: 53 ppb (annual mean)
 - California: 250 ppb (1 hour)
 - WHO (new): 20 ppb (annual mean)
100 ppb (1 hour)
- Formation on diesel catalytic trap



London experience

Contributions to NO₂ concentrations > 200 µg m⁻³ at Marylebone Road

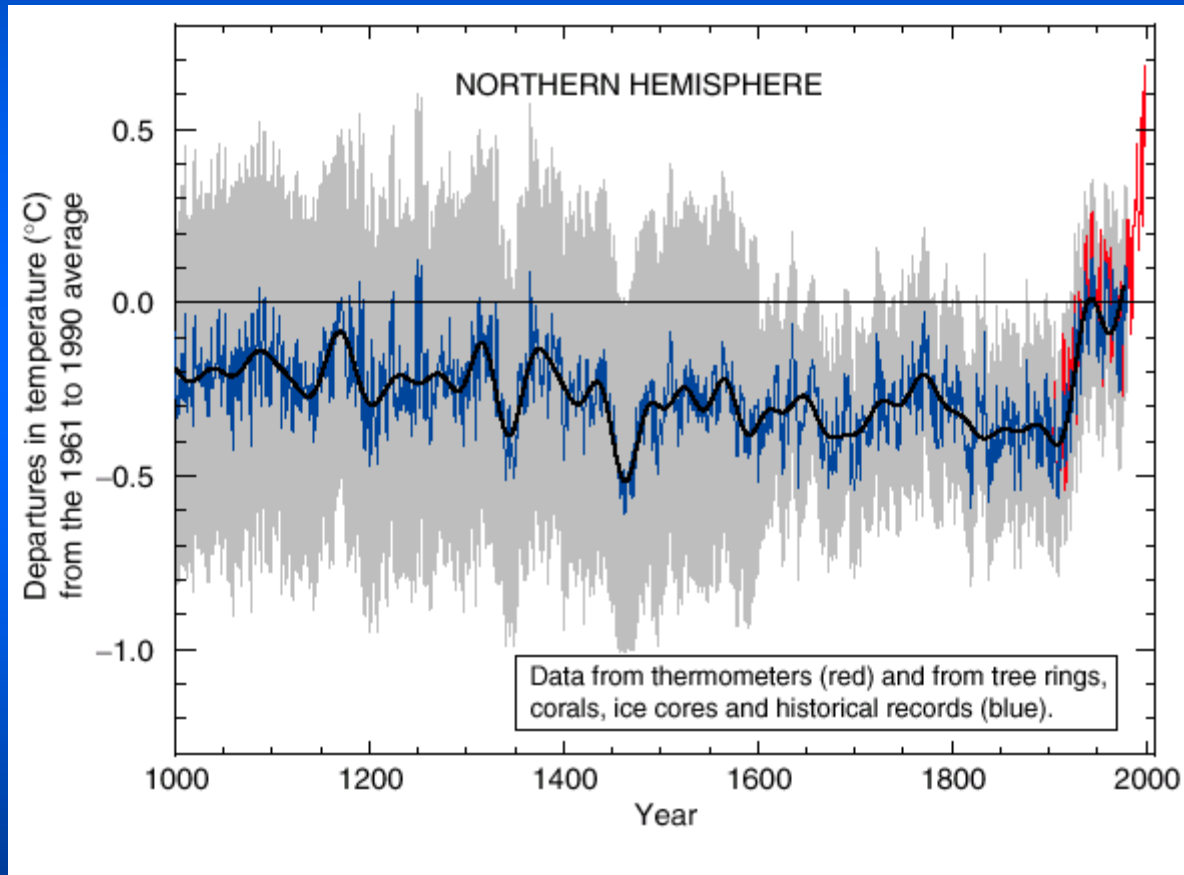


Regulatory Issue #4

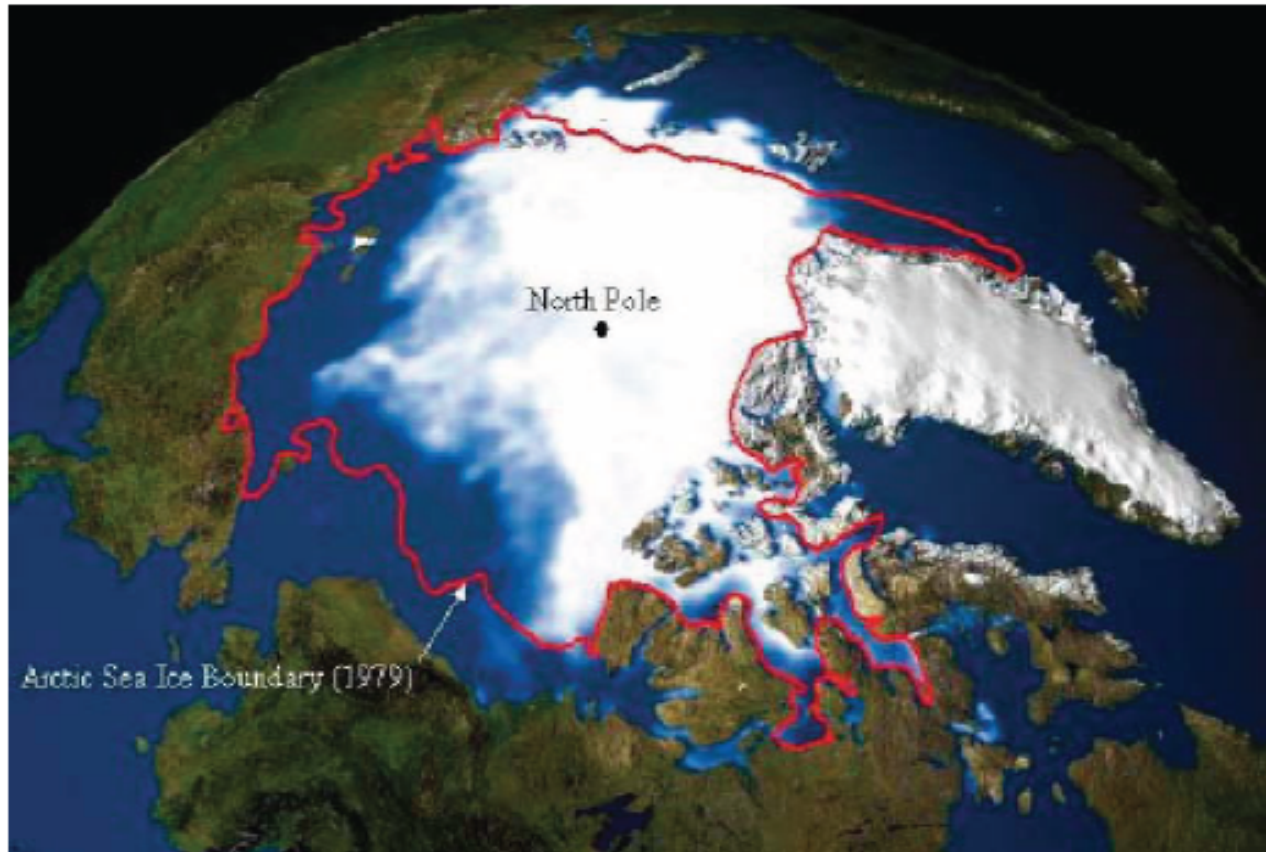
GLOBAL WARMING



Global warming evidence



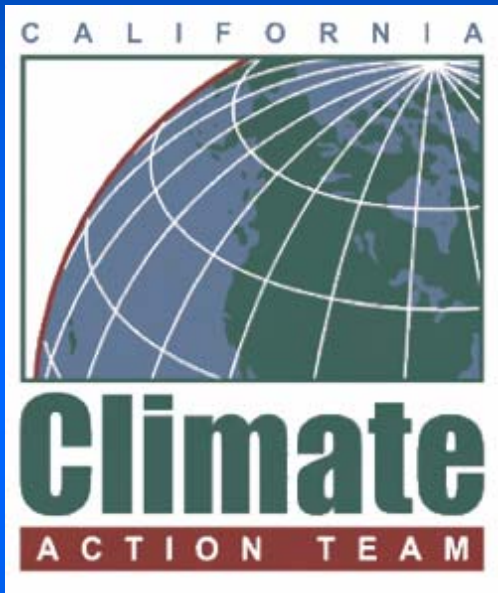
Climate change science drives policy decisions



Ice loss in the Arctic from 1979 - 2003 is greater than the land area of Texas, California and Maryland combined. Satellite image courtesy of NASA.



California initiatives



“...the debate is over. We know the science. We see the threat. And we know the time for action is now.”—Gov.

Schwarzenegger, 1 June 2005

Proposals include:

Mandatory greenhouse gas registry

Greenhouse gas cap and trade

Alternative transportation fuels

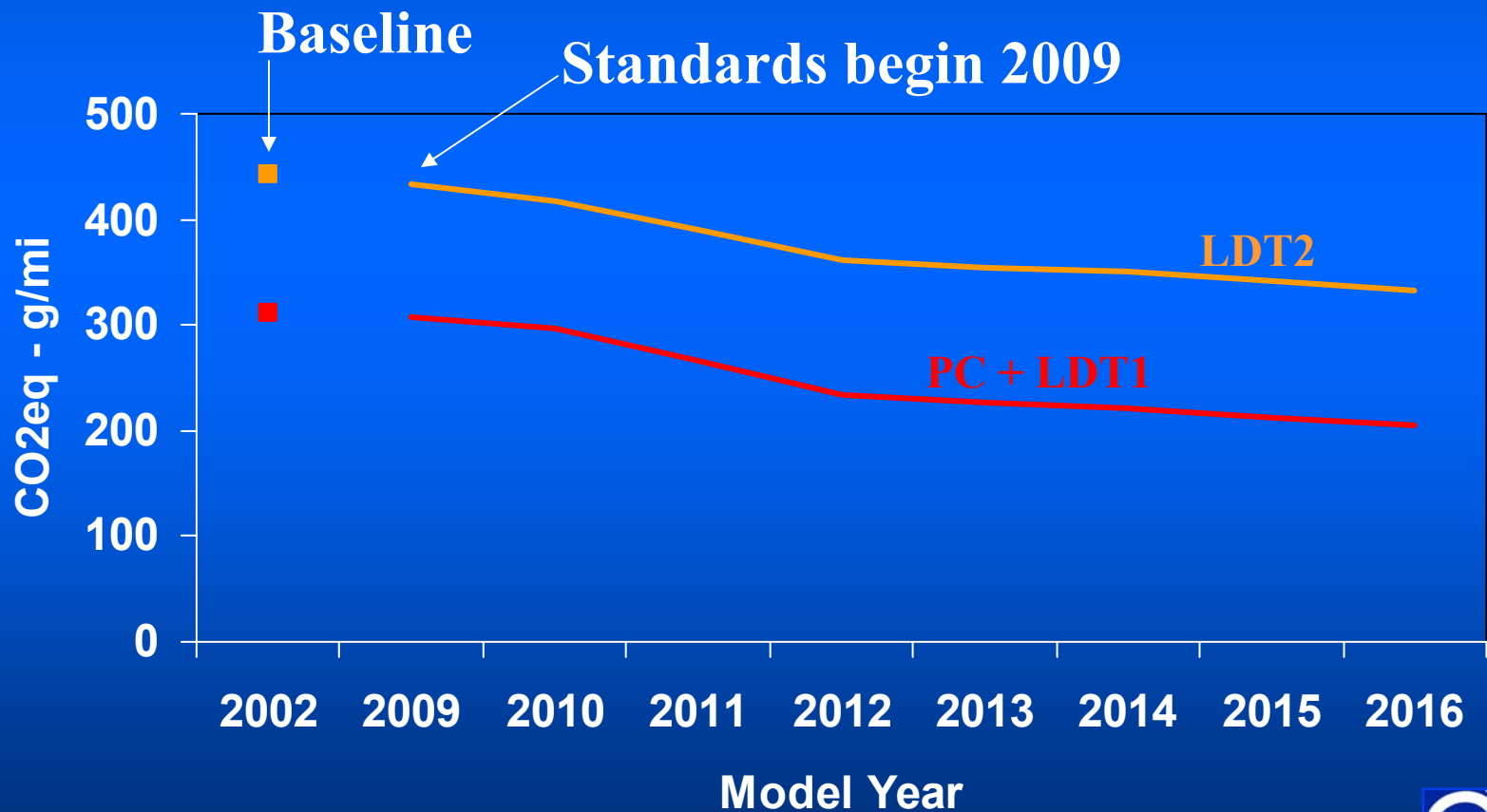


Motor vehicle climate change emissions control regulation (AB1493 Pavley)

- Light duty passenger cars and trucks
- CO₂, CH₄, N₂O, HFC
- 2009-2016 phase-in, fleet averaged
- 30% reduction (new vehicles)
- Cost effective to customer
- Based on existing technology
- Adopted by 10 states, 1/3 U.S. sales
- Legal challenge by automobile industry



Fleet average new vehicle $\text{CO}_{2\text{eq}}$ emissions

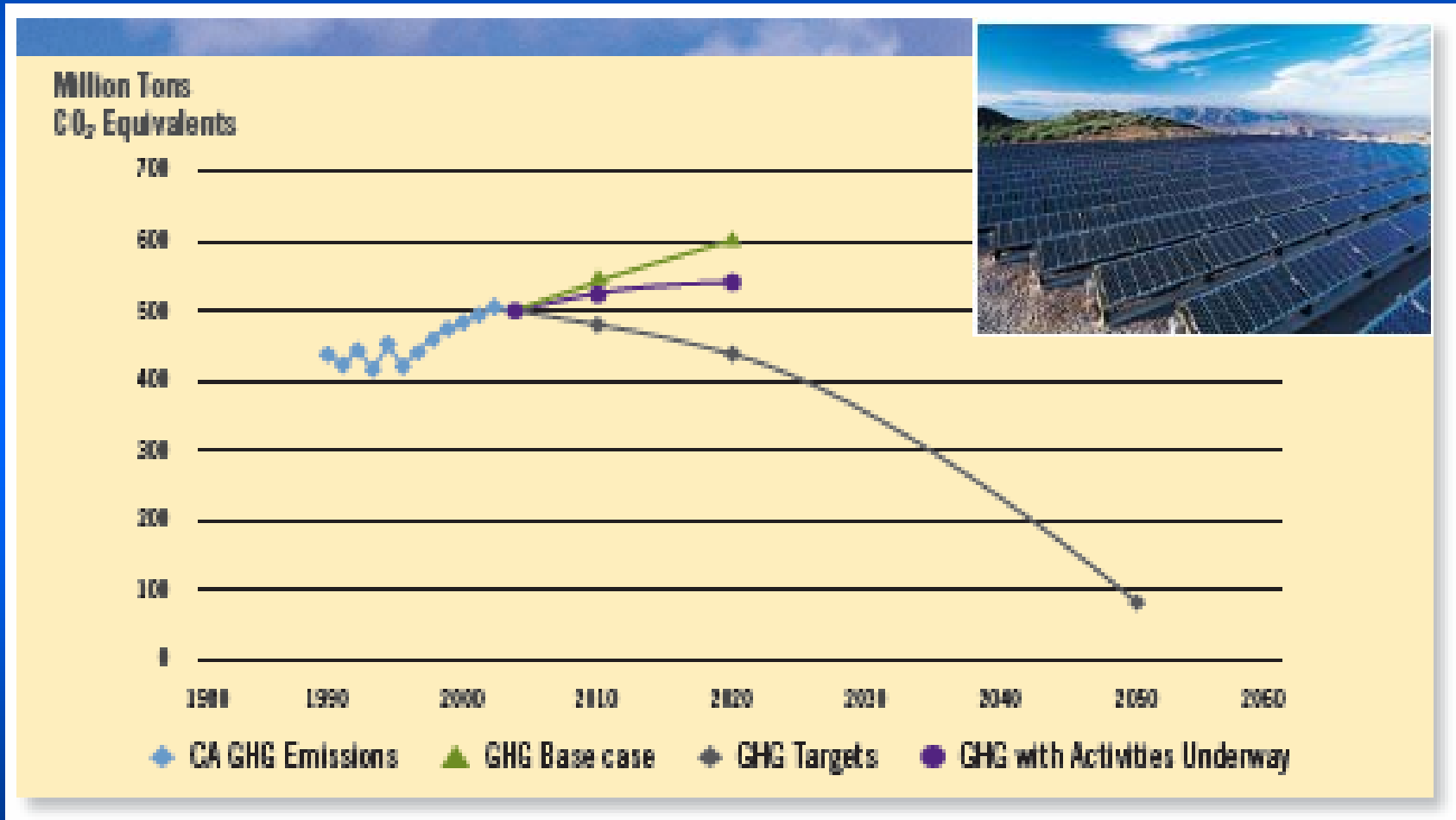


California Global Warming Solutions Act of 2006 (AB32)

- Reduce GHG emissions to 1990 levels by 2020 (30% reduction)
- Applies to Kyoto pollutants: CO₂, CH₄, N₂O, HFC, PFC, SF₆
- CARB implements most measures
- Detailed action schedule



California greenhouse gas emission trends (CEC, 2005)

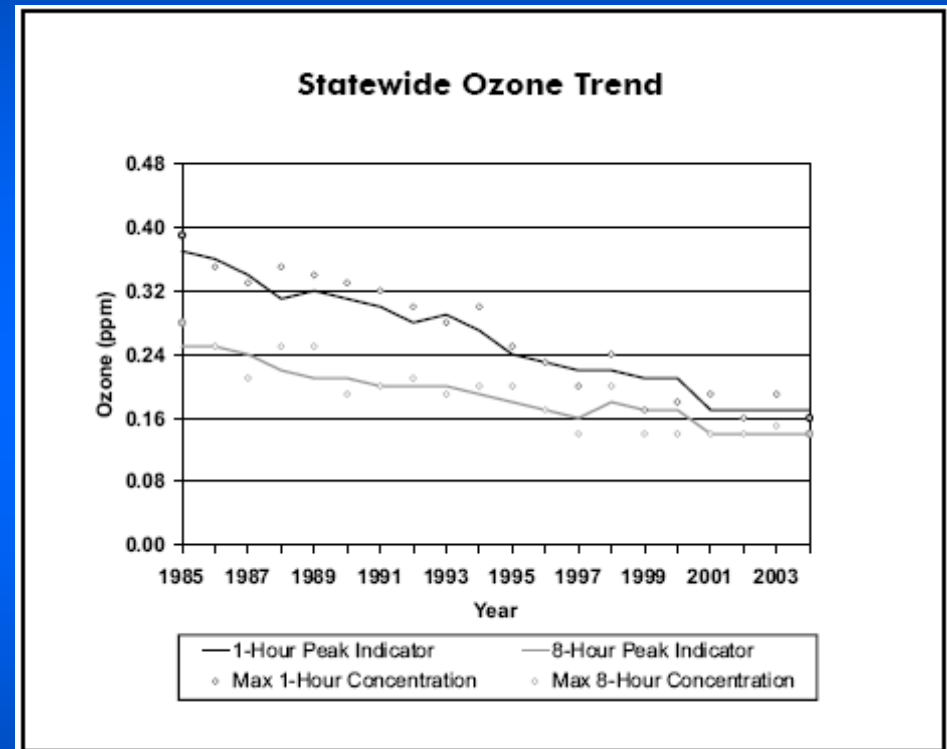


Some successes and challenges

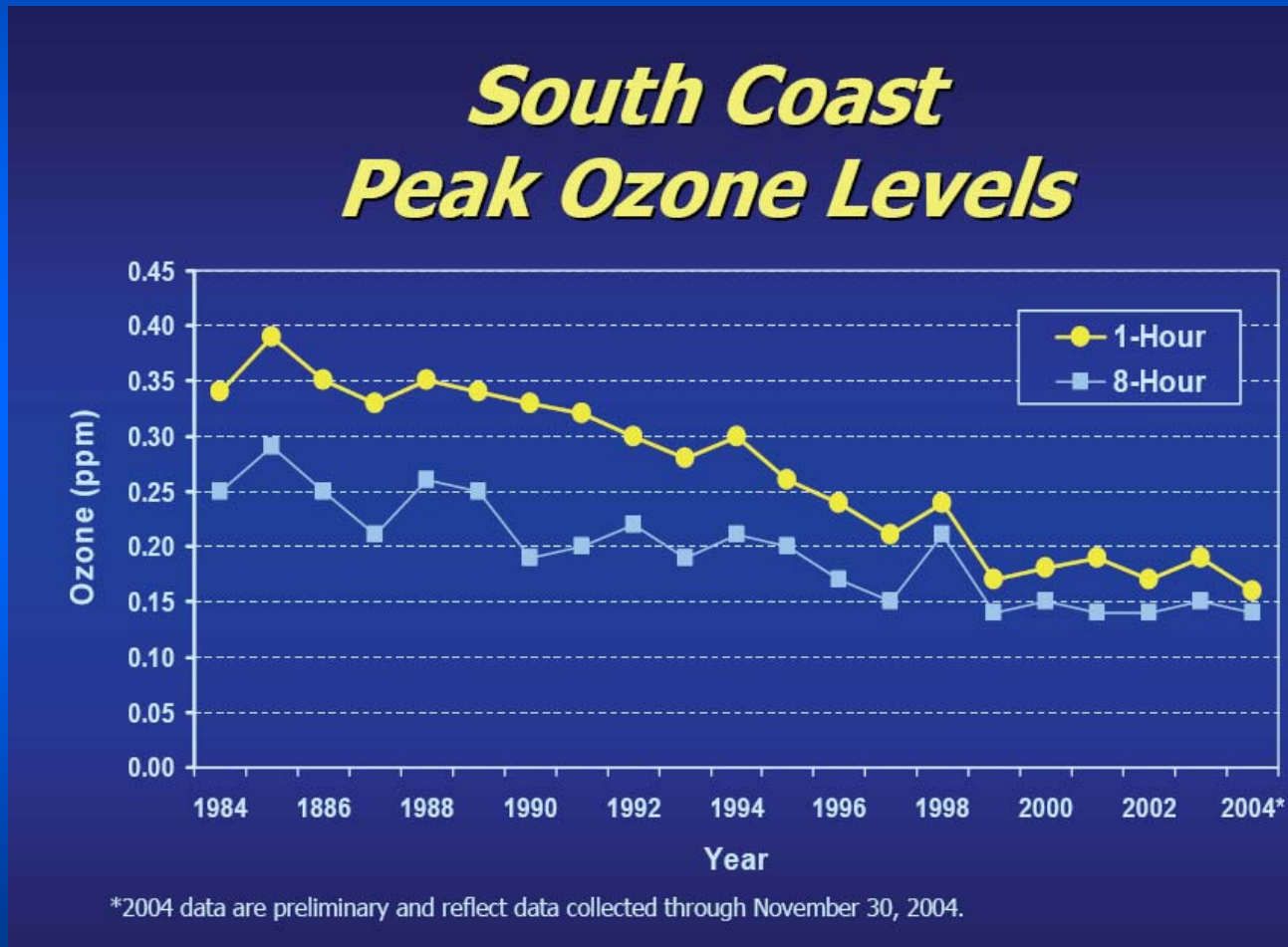


Success: air quality improving

- ✓ Lead
- ✓ Nitrogen dioxide
- ✓ Sulfur dioxide
- ✓ Carbon monoxide
- Ozone
- Particulate matter

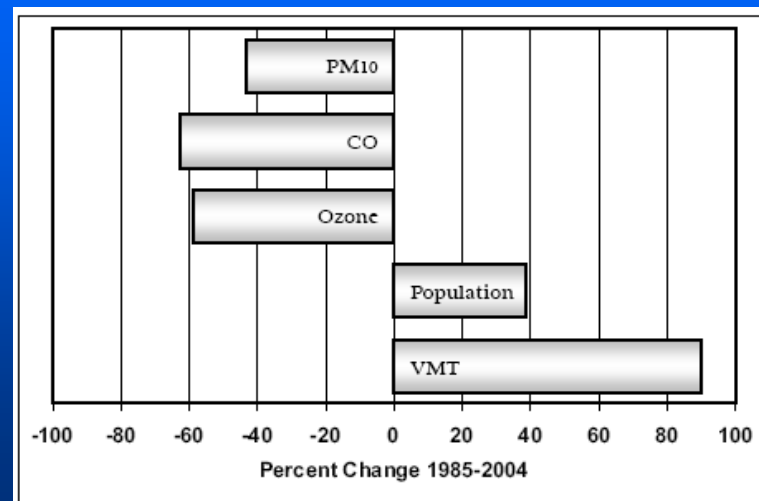


Success: South Coast ozone falling



Challenge: continuing growth

- Population
- Motor vehicles
- Motor fuel consumption
- Vehicle miles traveled
- Goods movement

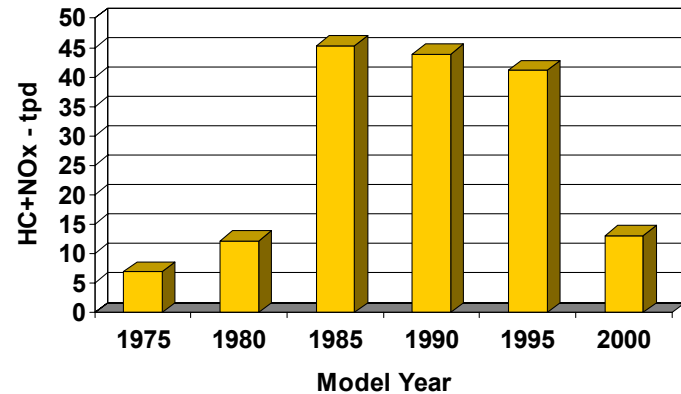
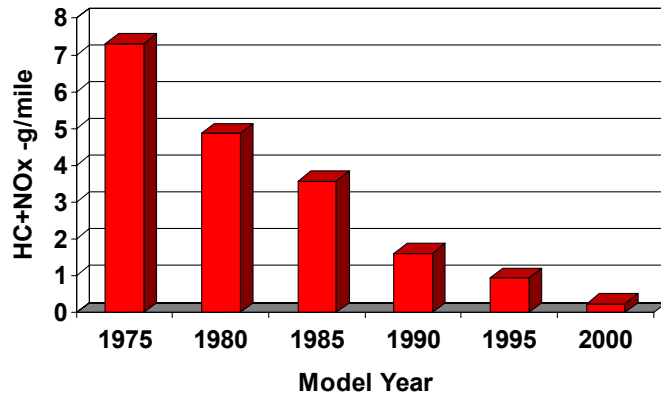


Success: new light duty fleet clean and durable

- Tailpipe emissions
- Evaporative emissions
- On-board diagnostics



Challenge: older, in-use light duty vehicles

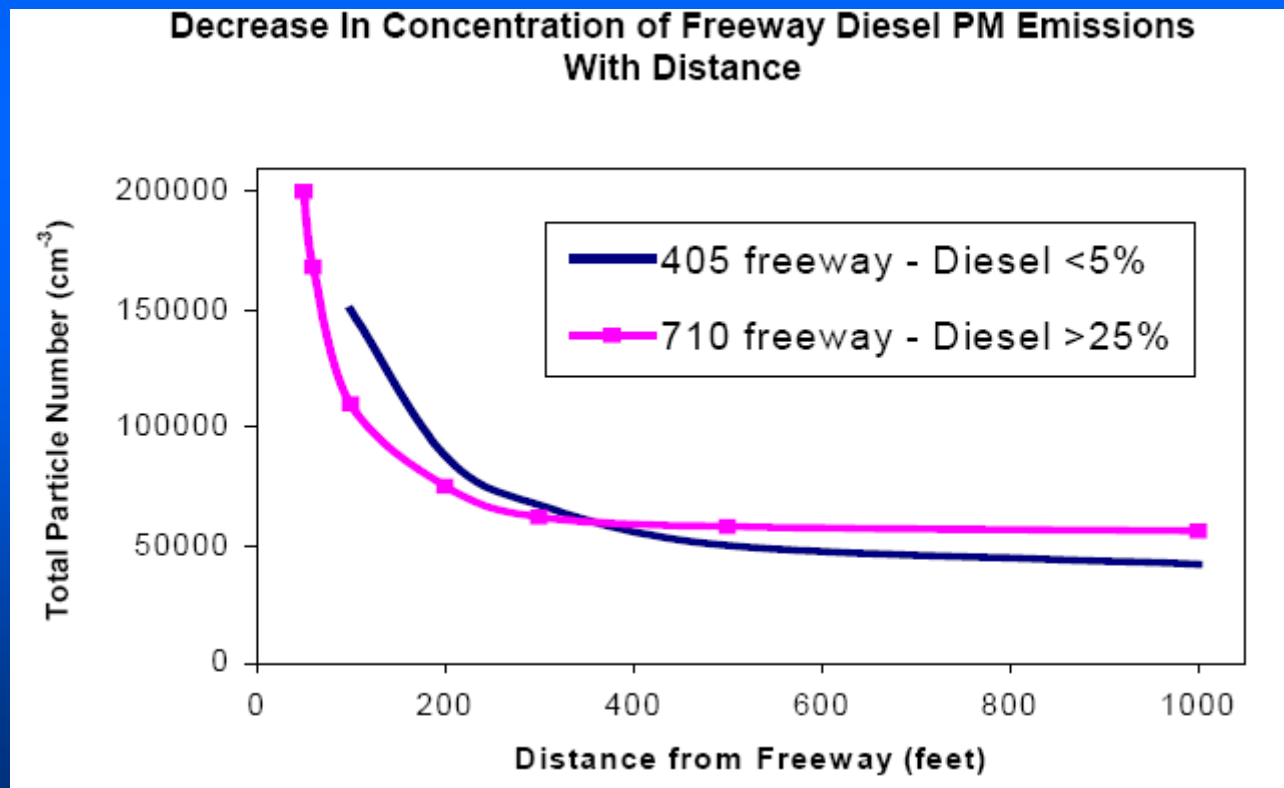


(in 2002)



Success/challenge: land-use planning

- Air Quality and Land Use Handbook: A Community Health Perspective



Challenge: ZEV program

- Battery electrics
- Fuel cell vehicles
- 2007 expert panel review



Success: ZEV program

- PZEVs
- Hybrids
- SULEVs



Challenge: transportation petroleum use reduction

- Reduce petroleum use 15% by 2020
- Increase alternative fuel use to 20% by 2020
- Focus on renewable, biofuels
- Ethanol: E10 or E85 or both?



Challenge: diesel risk reduction

- Goals set in 2000
 - 75% reduction by 2010
 - 85% reduction by 2020
- Approaches
 - New engine standards
 - In-use compliance (heavy duty I/M)
 - Clean diesel fuel, alternative fuels
 - Retrofit program
- Growth problem



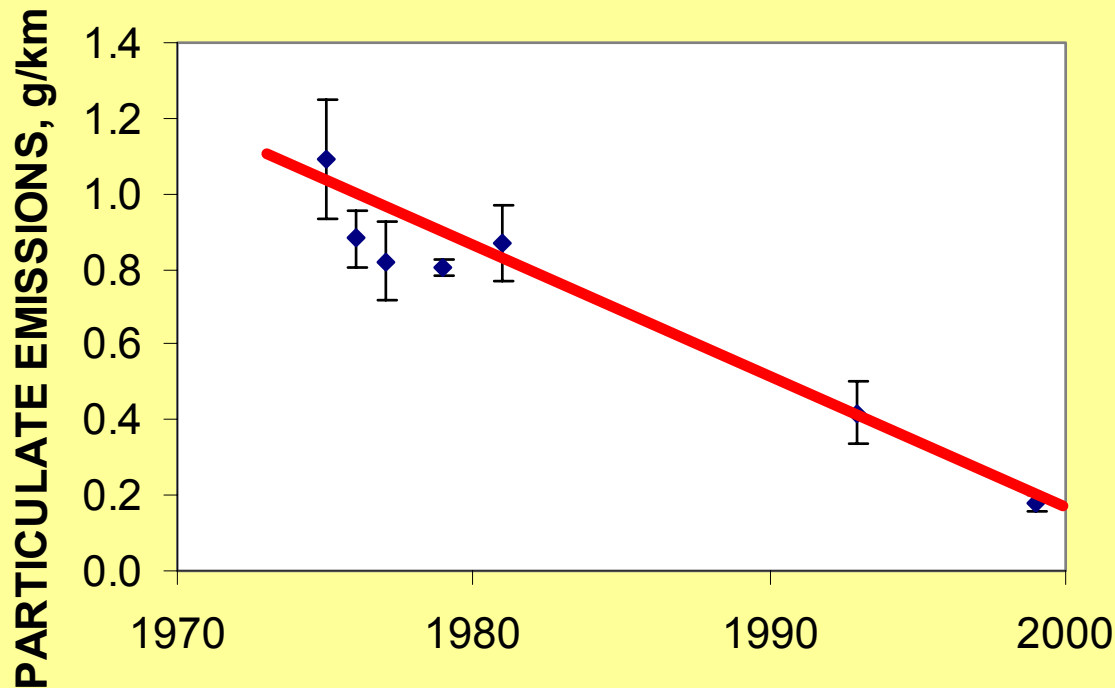
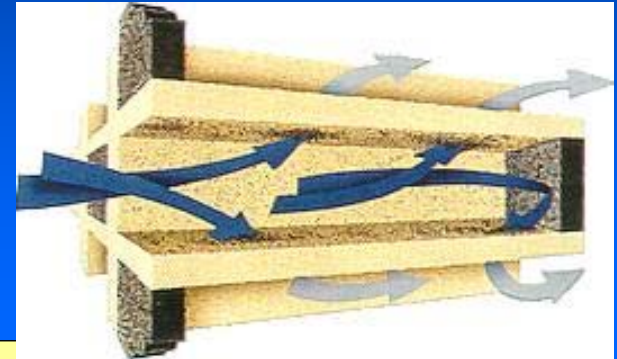
Success: clean light duty diesels

- Will meet California LEV II standards
- Multiple manufacturers are planning to introduce to California
- Fuel economy, performance
- Larger vehicles



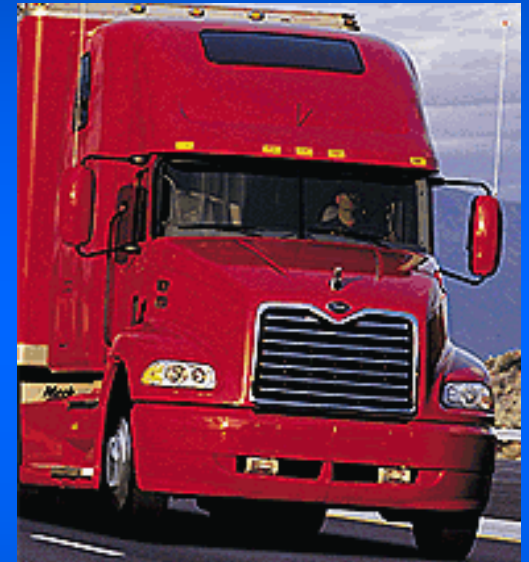
Success: heavy duty diesel PM reduction

- On-road evidence
- 2007 trap technology,
98% reduction



Challenge: heavy duty diesel NO_x reduction

- On-road emissions have not matched emission standards
- NO_x versus fuel economy trade-off
- 2010 standards, 98% reduction
 - Urea based selective catalytic reduction
 - Other approaches



In conclusion:

“If you enjoy challenges and successes, the Air Resources Board is a great place to work!” –R. Sawyer, November, 2006

